

TITLE: AQUEOUS BIPHASE EXTRACTION FOR PROCESSING OF FINE COALS **DATE:** April 1999
PI: K. Osseo-Asare
STUDENT: Xi Zeng, Ph.D. Candidate
INSTITUTION: Penn State University
Metals Science and Engineering Program
Department of Materials Science and Engineering
209 Steidle Building
Penn State University
University Park, PA 16802
(814) 865-4882
Email: asare@ems.psu.edu
GRANT NO.: DE-FG22-96PC96211
PERIOD OF PERFORMANCE: September 1, 1996 to April 30, 1999

ABSTRACT

OBJECTIVE

The objective of this research project is to develop an aqueous biphasic extraction process for the treatment of fine coal. Aqueous biphasic extraction is an advanced separation technique which relies on the ability of an aqueous system consisting of a water-soluble organic polymer and an inorganic metal salt to separate into two immiscible aqueous phases. Differences in the hydrophobic/hydrophilic properties of particulates can then be exploited to effect selective transfers to either the top polymer-rich phase, or the bottom salt-rich phase. An additional goal is to develop an improved coal-pyrite or other fine particles mixture separation technique based on aqueous biphasic extraction. The experimental program involves phase diagram determination, phase separation rate measurement, partition measurement, and washing experiments.

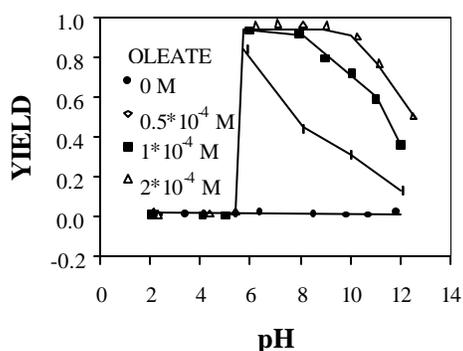
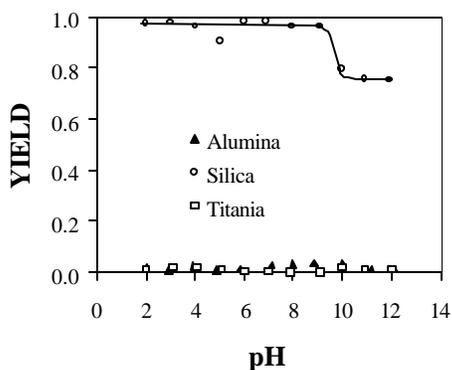
ACCOMPLISHMENTS TO DATE

The partitioning behaviors of alumina, hematite, pyrite, silica, and titania in PEG (polyethylene glycol)/Na₂SO₄/H₂O were systematically investigated; the effects of pH and surfactant addition were also studied. The partitioning of pyrite is highly dependent upon the pH of the system. Almost all the pyrite preferred the bottom phase for pH 9-13, and the top phase below pH 5. Between pH 5 and 8, almost all the pyrite distributed to the interface and there was little pyrite in the top and bottom phases. With SDS (sodium dodecyl sulfate) or oleic acid in the system, the partitioning behavior of pyrite remained the same. For 1×10⁻⁵ M xanthate in the aqueous biphasic system, some pyrite went into the top phase, but mostly, the solids stayed at the interface. When the concentration of xanthate increased to 1×10⁻³ M, almost all pyrite went into the top phase, for the entire pH range of 2 to 12.

The partitioning behaviors of alumina, hematite, silica, and titania were also investigated. In the pH range of 2 to 12, almost all of the alumina, hematite, and titania particles preferred the bottom phase (Fig. 1) because of the hydrophilic surfaces of these oxides. In

contrast, silica particles transferred into the top phase, a result which is attributable to PEG adsorption on silica particles. The presence of SDS and xanthate did not change the partitioning behavior of hematite in the PEG/Na₂SO₄/H₂O system. Below pH 6, addition of oleate had no effect on the partitioning behavior of hematite. However, above this pH, there was a dramatic increase in the yield of hematite in the top phase; particles transferred to the top phase at about pH 6, and the yield reached a maximum. With further pH increase, the yield began to decrease; the decrease was less pronounced as oleate concentration increased from 5×10⁻⁵ M to 2×10⁻⁴ M (as shown in Fig 2).

Fig 1. Yield of alumina, silica, and titania Fig 2. Effect of pH and oleate on the yield



in the top phase of the PEG-2000/Na₂SO₄/H₂O system.

of hematite in the top phase of the PEG-4600/Na₂SO₄/H₂O system.

SIGNIFICANCE TO FOSSIL ENERGY PROGRAMS

Ever-stringent environment constraints dictate that future coal cleaning technologies be compatible with micro-size particles. For super-clean coal production, the degree of liberation needed to separate coal from mineral matter, including pyrite, requires grinding to 10 μm or below. In addition, large amounts of fine coal are discharged to refuse ponds because current coal cleaning technology cannot adequately treat such finely divided materials. This research program, based on aqueous biphasic extraction, seeks to develop an advanced coal cleaning technology uniquely suited to micro-size particles.

PLANS FOR THE COMING YEAR

Work in the coming year will involve the following experiments: (1) Partitioning behavior of coal and other mineral particles in PEG/salt/water systems. (2) The adsorption of PEG on pyrite surface, and the effect of pH and inorganic salts. (3) The adsorption density of PEG on silica surface, and the effect of ionic strength and pH. Also included will be the effect of PEG adsorption on silica zeta potential, and the molecular conformation of PEG adsorbed on the silica surface. (4) The adsorption of oleic acid on hematite surface, and the effect of PEG, inorganic salts, and pH.

ARTICLES, PRESENTATIONS, AND STUDENT SUPPORT

Journal articles and presentations

- K. Osseo-Asare, X. Zeng; "Partition of Pyrite in Aqueous Biphasic Systems," *International Journal of Mineral Processing*, (submitted).
- X. Zeng, W. McGaulley, K. Osseo-Asare; "Pyrite Partition in Aqueous Biphasic Systems," presented at the 72nd ACS Colloid & Surface Science Symposium, Penn State University, University Park, 1998.
- K. Osseo-Asare, X. Zeng, "Aqueous Biphasic Extraction of Particulates: Controlling the Hydrophilic/Hydrophobic Balance for Separations," to be presented at the Engineering Foundation Symposium on Metal Separation Technologies Beyond 2000: Integrating Novel Chemistry With Processing, Hawaii, June, 1999; to be published in the proceedings volume, Kona Liddell, ed., TMS, Warrendale, PA, 1999.

Student supported under this grant

- Xi Zeng, graduate (Ph.D.) student in Materials Science and Engineering, Penn State University.